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Mowry

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(54) **INTERCONNECT DEVICE WITH OPPOSINGLY ORIENTED CONTACTS**

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(52) **U.S. Cl.** **439/66**
(58) **Field of Search** 439/66, 67, 70–71, 439/525–526, 862, 74, 83; 29/884, 874, 877, 29/825, 829; 361/760, 772

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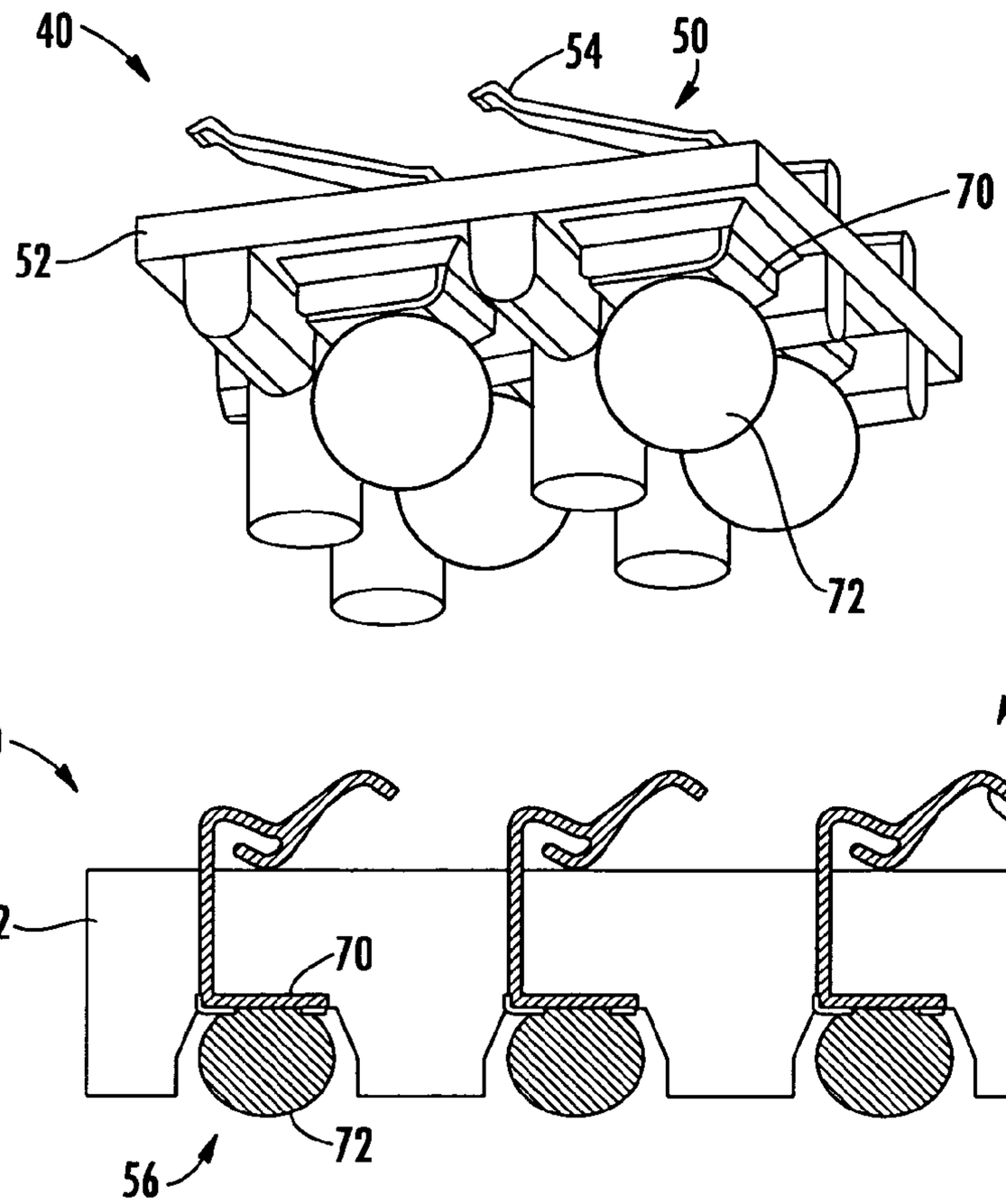
(57) **ABSTRACT**

An interconnect device for electrically interconnecting two components is disclosed. According to various embodiments, the interconnect device includes a frame having a upper side and a lower side, a first plurality of beam contacts on the upper side for connection to contacts of the first component, and a second plurality of contacts on the lower side of the frame for connection to contacts of the second component. The beam contacts on the upper side of the frame are arranged so that the sum of the sideways wipe forces caused by compression of the beam contacts on the upper side due to connection of the first component to the interconnect device approximately equals zero.

24 Claims, 6 Drawing Sheets



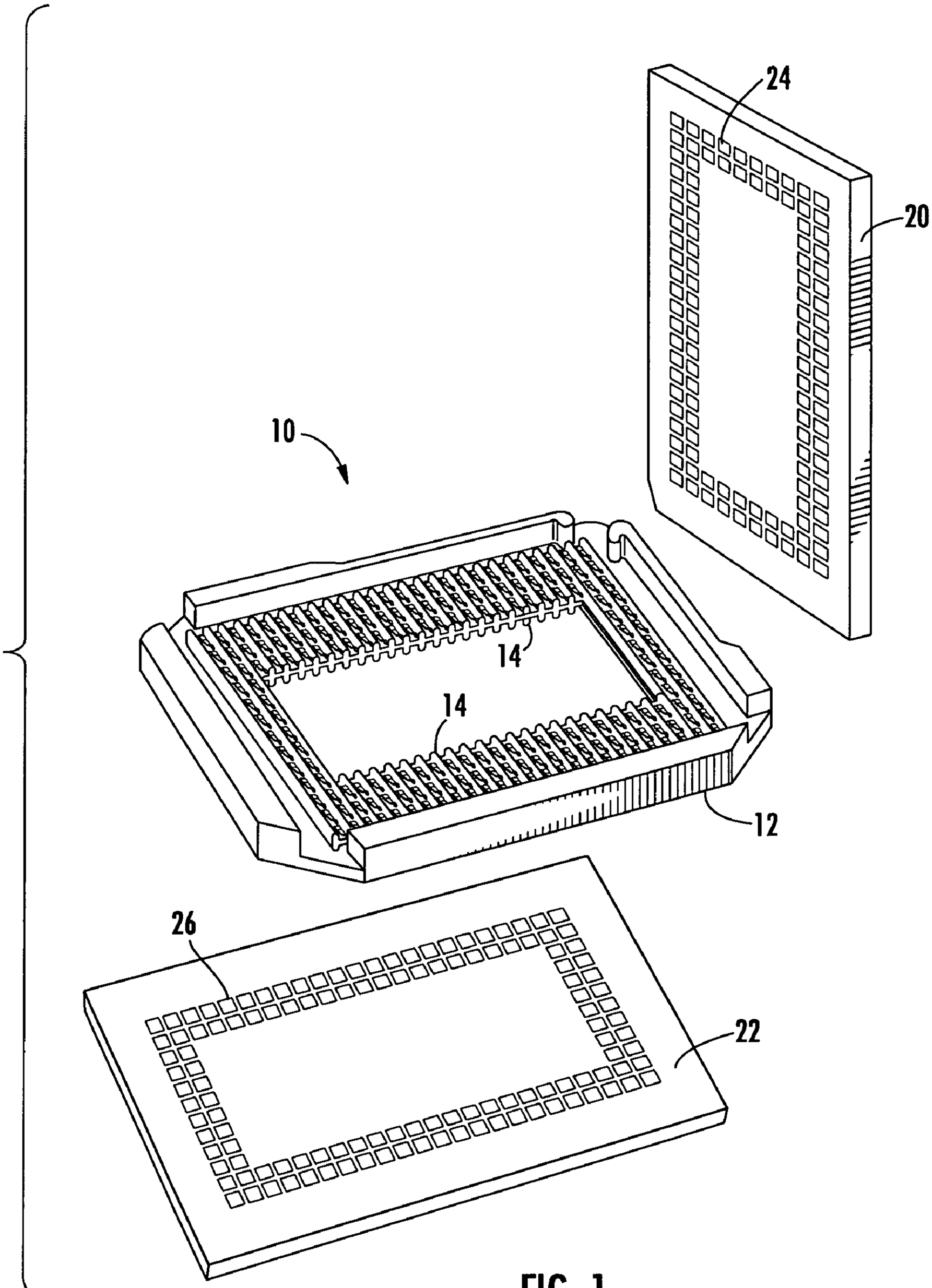


FIG. 1
(PRIOR ART)

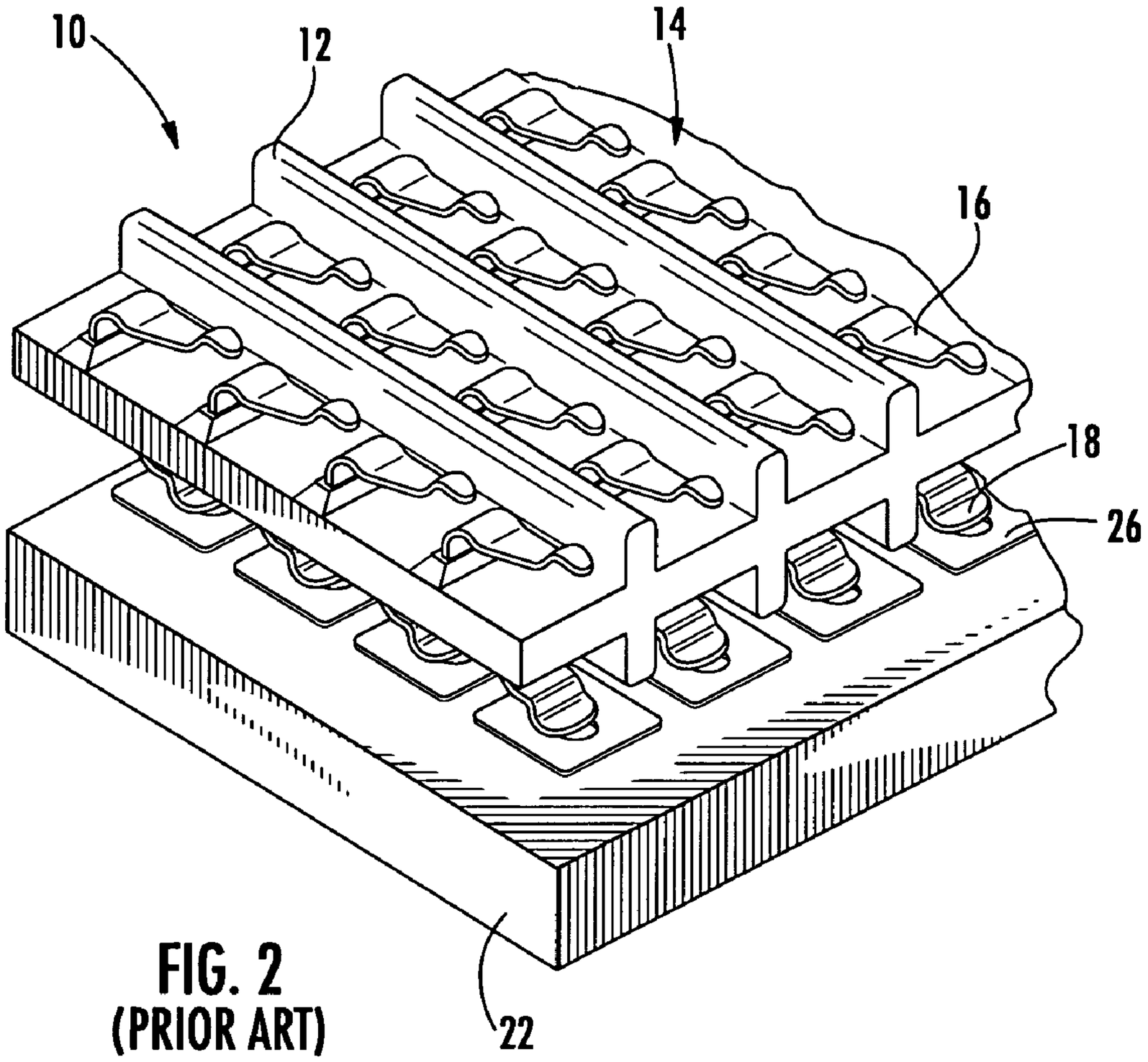


FIG. 2
(PRIOR ART)

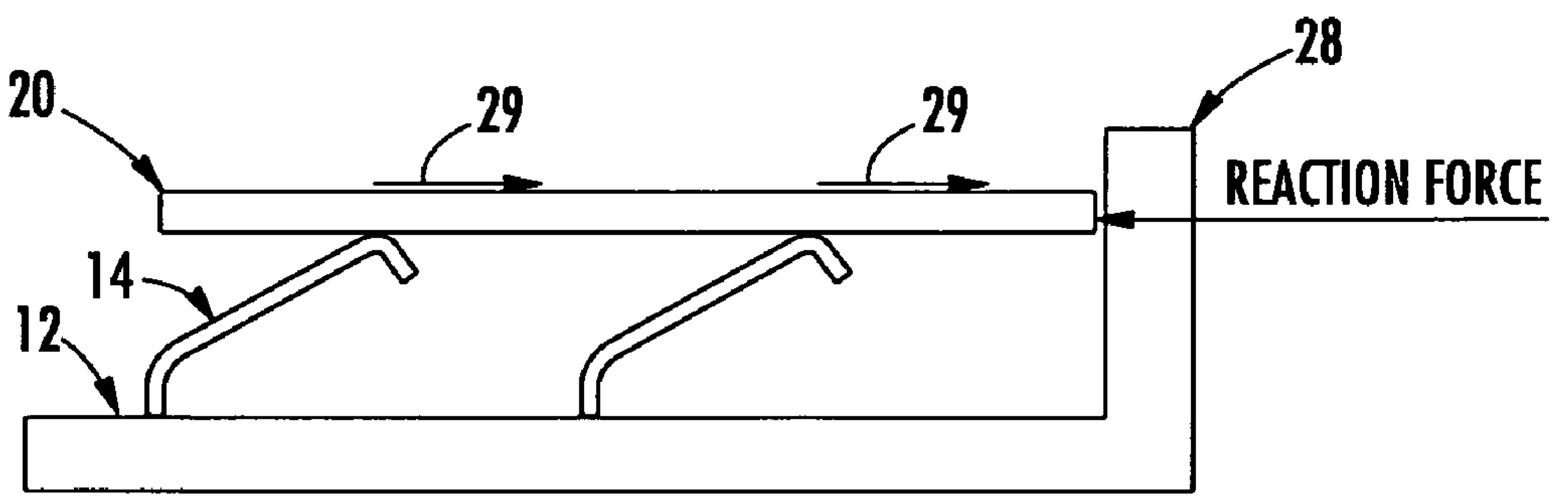


FIG. 3
(PRIOR ART)

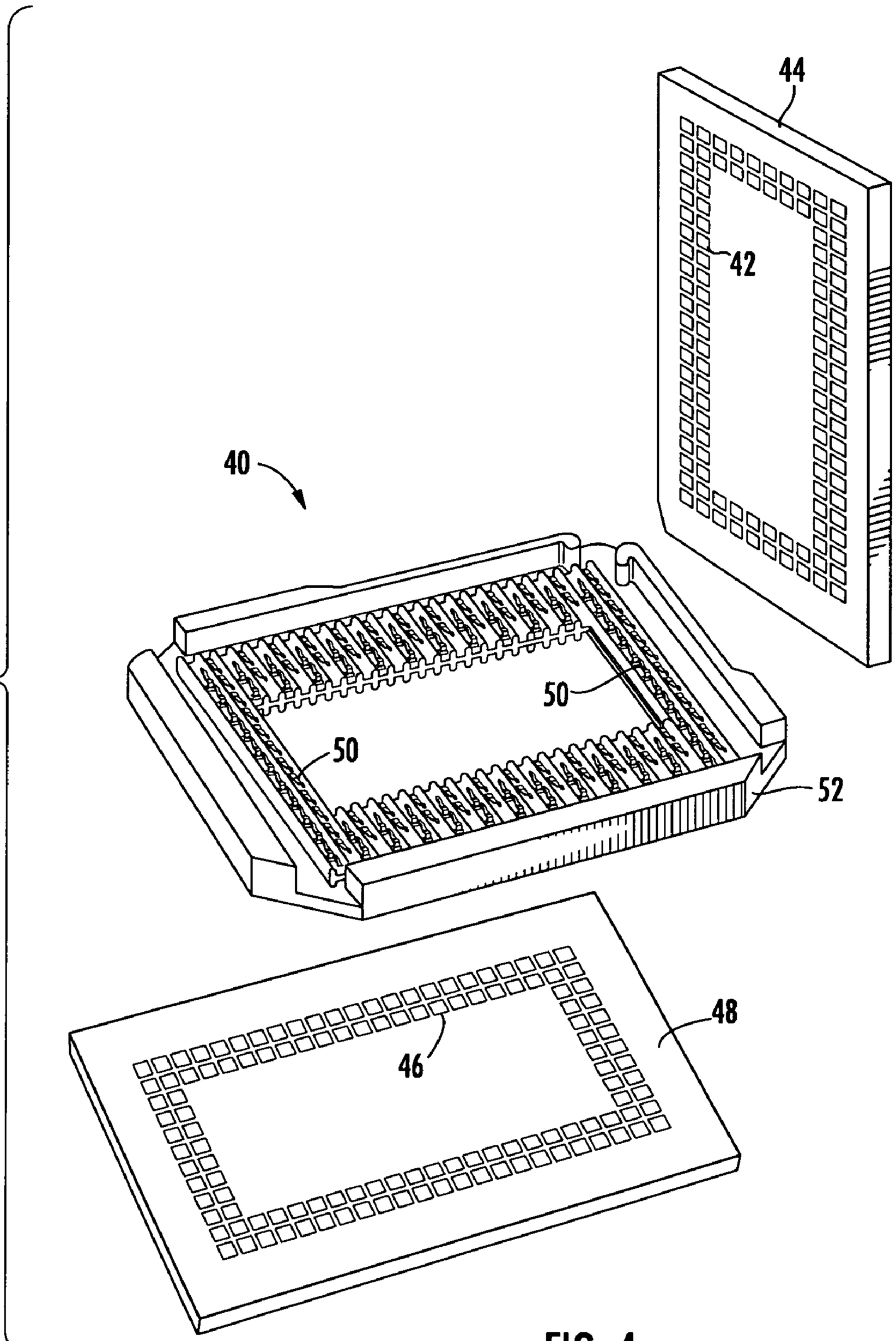


FIG. 4

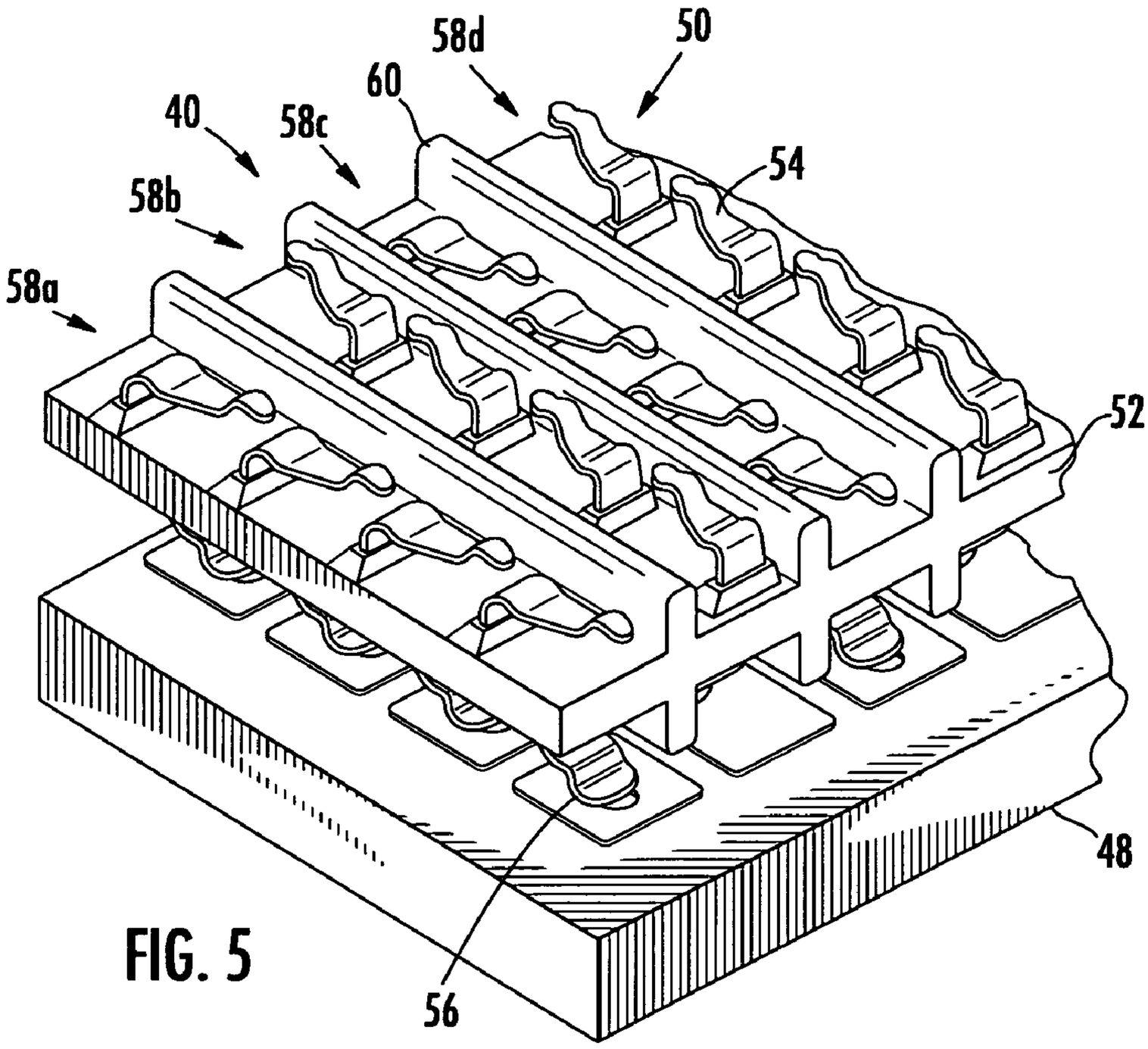


FIG. 5

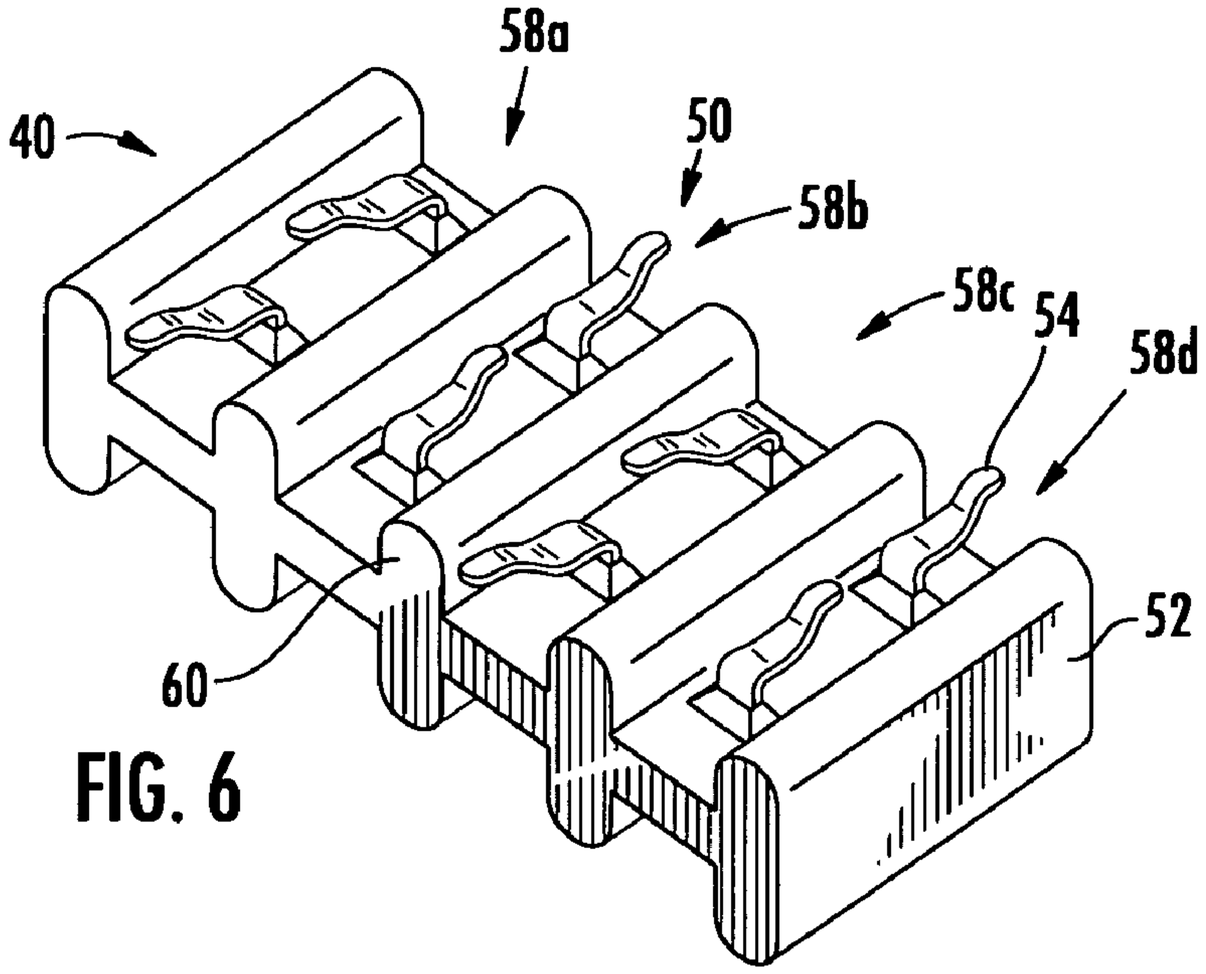


FIG. 6

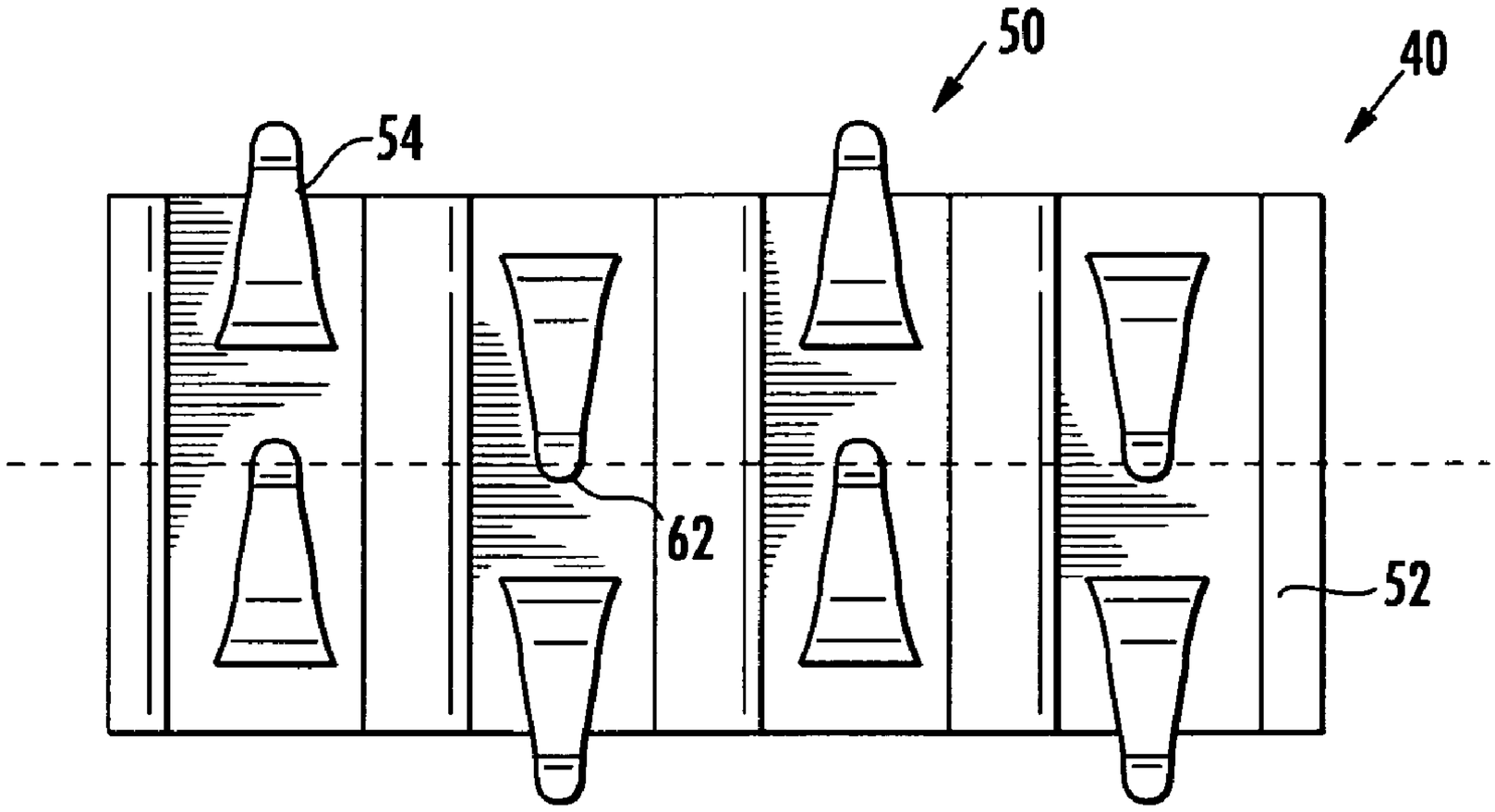


FIG. 7

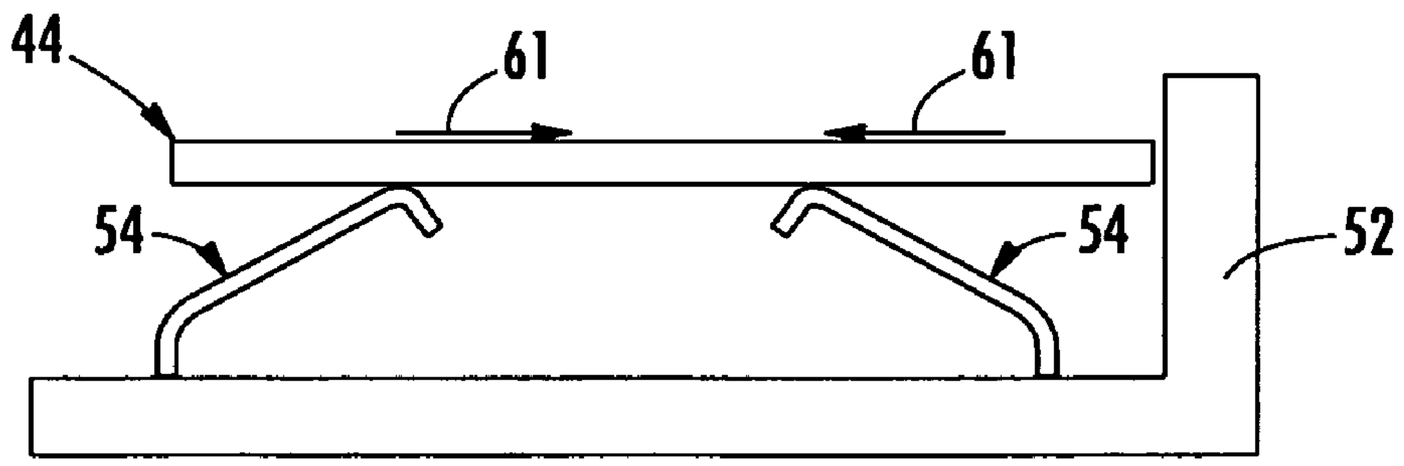


FIG. 8

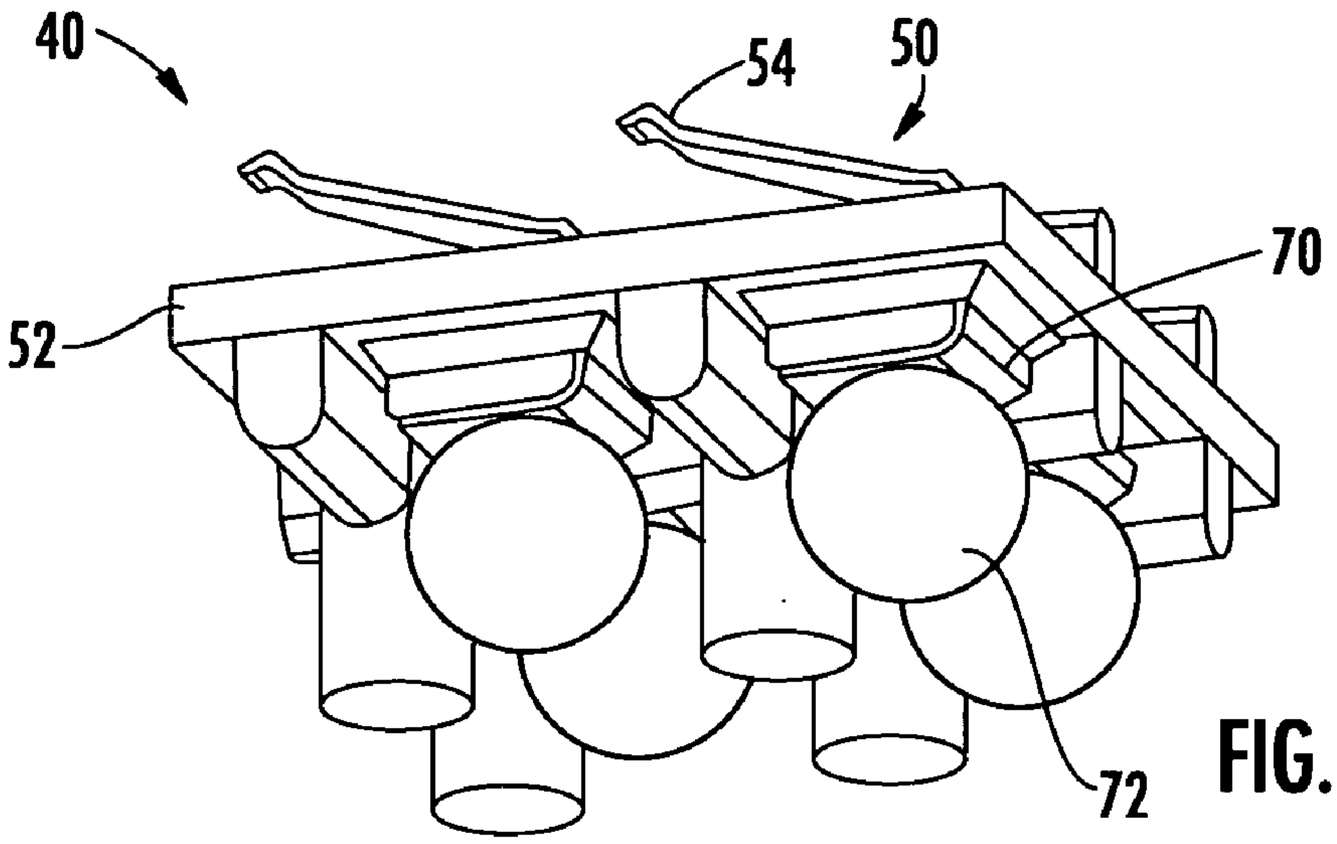


FIG. 9

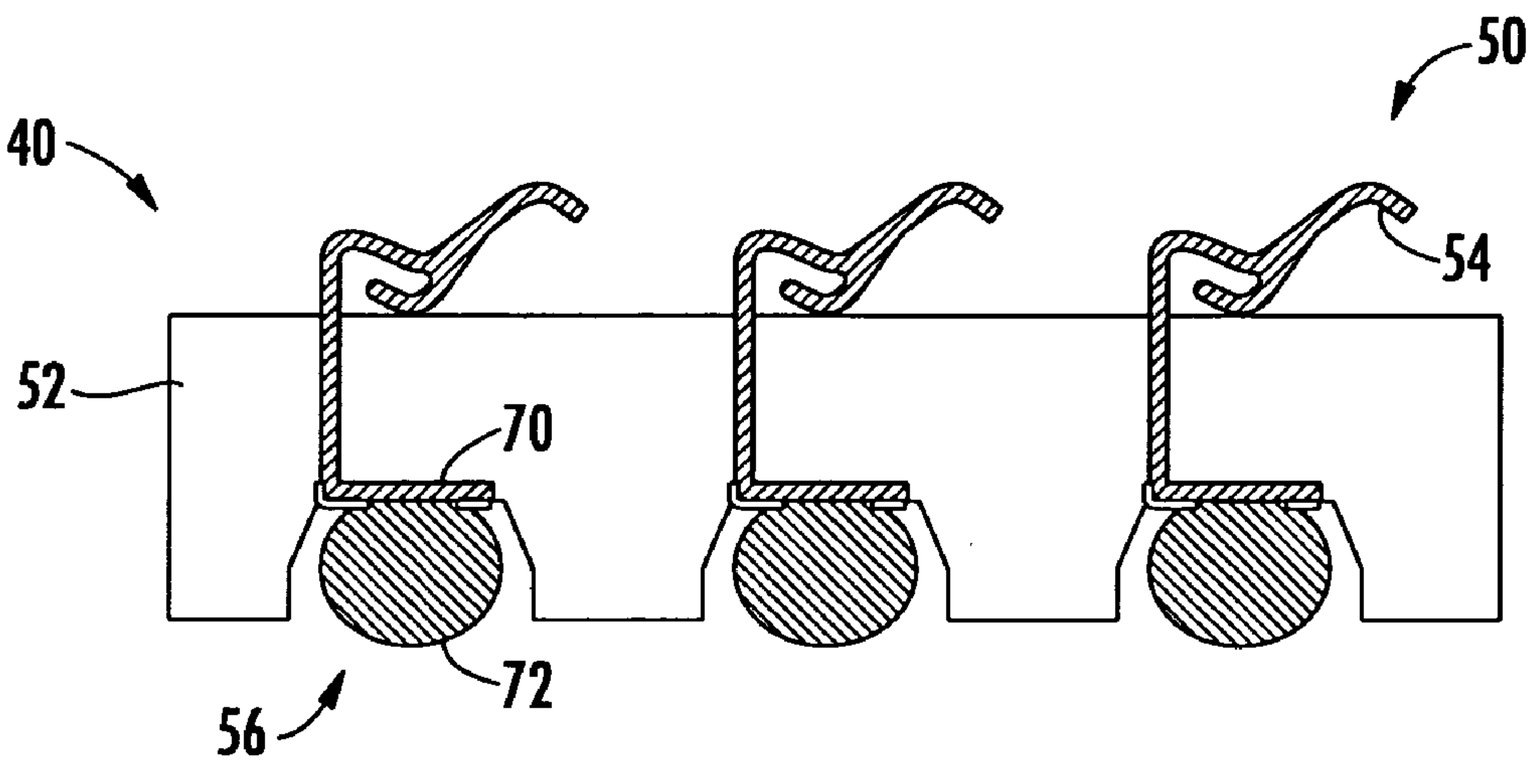


FIG. 10

INTERCONNECT DEVICE WITH OPPOSINGLY ORIENTED CONTACTS

BACKGROUND OF INVENTION

The present invention pertains to interconnect devices for electrically interconnecting the contacts of a first component to contacts of a second component.

An electrical interconnector having a plurality of electrical conductors can be used to interconnect one electronic component, such as a microprocessor or ASIC, to another electronic component, such as a printed circuit board. Typically, interconnect devices include a frame having two opposed contact surfaces for respective engagement with a corresponding contact surface of one of the electronic components. Electrical conductors (or contacts) on each side of the frame are electrically connected to the contacts of the respective components such that the two components are thereby electrically connected. The frame of the interconnect device functions to secure the positions of the electrical conductors relative to one another and to electrically isolate the electrical conductors from one another.

Today's microprocessors and ASICs often have thousands of densely spaced contacts. Correspondingly, interconnect devices for such components must have thousands of densely spaced contacts. One such known interconnect device is shown in FIGS. **1–2**. The interconnect device **10** includes a frame **12** having a number of electrical conductors **14**. Each conductor **14** has a beam contact portion **16**, **18** on opposite sides of the frame **12** such that there is an electrical connection between the two contact portions **16**, **18**. The interconnect device **10** electrically connects the first component **20** to the second component **22**. As such, the first component **20** includes a plurality of spaced apart contacts **24** for connection to the contact portions **16** and the second component **22** includes a plurality of spaced apart contacts **26** for connection to the contact portions **18**. Accordingly, each electrical conductor **16** establishes an individual electrical connection between a contact **24** of the first component **20** and a contact **26** of the second component **22**.

For a interconnect device **10** such as illustrated in FIGS. **1–2**, when the beam contacts **16**, **18** are compressed due to placement of the first and second components **20**, **22** on the device **10**, the beam contacts move in an arc and thereby generate a wiping action against a mating surface **28** of the frame **12**, resulting in a sideways force (the "wipe force") **29**, as shown in FIG. **3**. Although the individual wipe force from one beam contact may be relatively small, for electrical devices having thousands of densely spaced contacts the cumulative wipe force of all the beam contacts of the interconnect device can be quite high. For example, testing of such devices has shown that for a interconnect device having 2400 contacts, the cumulative sideways wipe force can be twenty pounds. This can be problematic. As the conductors are compressed, the contacts must be kept in proper alignment to the mating surfaces of the components to be connected together. Such a large wipe force limits how the parts can be kept in alignment because many alignment techniques cannot withstand such large sideways wipe forces.

One known technique of mitigating this problem is to use a contact that does not generate a wipe action. Such contacts, however, lose the cleaning action that the wipe action provides. Other drawbacks of such contacts include deflection range and cost. Another known technique is to use alignment techniques that can withstand such large wipe forces, such as using large, sturdy alignment surfaces and/or

alignment pins. While such techniques may be acceptable for some applications, such large sidewalls and/or alignment pins can present space and tolerance problems in other applications.

Accordingly there exists a need for an interconnect device that minimizes or eliminates the cumulative wipe forces, yet provides the beneficial wipe action, is relatively inexpensive to manufacture, and which has the capability of satisfying tight and/or small dimensional requirements.

SUMMARY OF THE INVENTION

In one general respect, embodiments of the present invention are directed to an interconnect device for electrically interconnecting a first component to a second component. According to various embodiments, the interconnect device includes a frame having a upper side and a lower side, a first plurality of beam contacts on the upper side for connection to contacts of the first component, and a second plurality of contacts on the lower side of the frame for connection to contacts of the second component. Each beam contact on the upper side of the frame is electrically connected to a contact on the lower side of the frame. In addition, the beam contacts on the upper side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the beam contacts on the upper side of the frame due to connection of the first component to the interconnect device approximately equals zero or is below some threshold amount, such as 5 pounds. For example, a first portion of the first plurality of beam contacts may be oriented to face a first direction and a second portion of the second plurality of beam contacts may be oriented to face a second direction opposite to the first.

According to various other embodiments, the second plurality of contacts, on the lower side of the frame, may include beam contacts. The beam contacts on the lower side of the frame may also be arranged so that the sum of the sideways wipe forces caused by compression of the beam contacts on the lower side due to connection of the second component to the interconnect device approximately equals zero or is below the threshold amount. In addition, the first component may be, for example, an integrated circuit and the second component may be a printed circuit board (PCB).

According to another embodiment, the first plurality of beam contacts, on the upper side of the frame, may be arranged in columns such that the beam contacts in a first portion of the columns are oriented in a first direction and the beam contacts in a second portion of the columns are oriented in an opposite direction relative to the first direction, such that the sum of the sideways wipe forces caused by compression of the beam contacts in the first and second portions of the columns due to connection of the first component to the interconnect device approximately equals zero or is below the threshold amount. The plurality of beam contacts on the lower side of the frame may be similarly arranged.

In another general respect, embodiments of the present invention are directed to a method of fabricating an interconnect device for electrically interconnecting a first component to a second component. The method includes molding a frame of the interconnect device such that a plurality of electrical conductors are molded into the frame, wherein each electrical conductor includes a first beam contact portion extending from an upper side of the frame and a second beam contact portion extending from a lower side of the frame. The method further includes shaping the electrical conductors such that the first beam contact portions extend-

ing from the upper side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the first beam contact portions due to connection of the first component to the interconnect device approximately equals zero or is below the threshold amount. In addition, the method may include shaping the electrical conductors such that the second beam contact portions extending from the lower side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the second beam contact portions due to connection of the second component to the interconnect device approximately equals zero or is below the threshold amount.

DESCRIPTION OF THE FIGURES

Embodiments of the present invention are described by way of example in conjunction with the following figures, wherein:

FIGS. **1–2** depict a prior art interconnect device;

FIG. **3** is a diagram illustrating sideways wipe forces in a prior art interconnect device;

FIGS. **4–7** depict an interconnect device according to various embodiments of the present invention;

FIG. **8** is a diagram illustrating the cancellation of the sideways wipe forces with an interconnect device according to various embodiments of the present invention; and

FIGS. **9–10** illustrate an embodiment of the interconnect device according to various embodiments of the invention with solder balls connected to one side thereof.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. **4–7** depict an interconnect device **40** according to various embodiments of the present invention. The interconnect device **40** may be used to electrically interconnect contacts **42** on a first component **44** to corresponding contacts **46** a second component **48**. FIG. **4** is a perspective view of the interconnect device **40** together with the first and second components **44, 48**. FIG. **5** is a perspective side view of a portion of the interconnect device **40** with a portion of the second (e.g., bottom) component **48**. FIG. **6** is another perspective view of a portion of the interconnect device **40** and FIG. **7** is a top plan view of a portion of the interconnect device **40**.

The contacts **42, 46** may be, for example, lands or pads of various shapes and sizes. For example, as illustrated in FIG. **4**, each contact **42, 46** may be a land that is a rectangular shaped flat surface. The plurality of contacts **42, 46** of the first and second components **44, 48**, arranged in rows/columns as shown in FIG. **4**, may be considered to constitute a "land grid array." The first component **44** may be an integrated circuit such as, for example, a microprocessor or an ASIC. The second component **48** may be, for example, a printed circuit board (PCB). As such, the interconnect device **40** may be referred to as a "microprocessor connector," a "socket," an "interposer," or a "land grid array (LGA) socket."

According to various embodiments, as shown in FIGS. **4–7**, the interconnect device **40** includes a number of electrical conductors **50** extending through a frame **52**. Each conductor **50** may include a beam contact portion **54** on an upper side of the interconnect device **40** and a beam contact portion **56** on a lower side of the interconnect device **40**. The upper beam contact portions **54** may contact respective and corresponding contacts **42** on the first component **44** and the lower beam contact portions **56** may similarly contact respective and corresponding contacts **46** on the second component **48**. As such, the electrical conductors **50** may provide an electrical connection between the contacts **42** of the first component **44** and the corresponding contacts **46** of the second component **48**.

The electrical conductors **50** may be fabricated from an electrically conductive material such as, for example, BeCu. The electrical conductors **50** may be stamped or formed from metallic strips that are approximately 0.001 to 0.003 inches in thickness. Further, portions of the electrical conductors **50** may be completely or selectively gold-plated on one side to a thickness of between three and fifty micro-inches to enhance the conductivity of the conductors **50**. The conductors **50** may be spaced, for example, 1 mm apart.

The frame **52** may be made from an electrically non-conductive material, such as thermoplastic, to provide electrical insulation between the numerous conductors **50**. The shape, size and design of the frame **52** can be varied to be compatible with particular variations of the first and second components **44, 48**.

According to various embodiments, as shown in FIGS. **4–7**, the frame **52** may define a number of channels **58** on both the upper and lower surfaces thereof. The channels **58** may be separated by raised sidewalls **60** on both the upper and lower surfaces of the frame **52**. The beam contact portions **54, 56** may be positioned in the respective channels **58**.

In the illustrated embodiments of FIGS. **4–7**, the conductors **50** have compression-type beam contact portions **54, 56**. As such, when the beam contact portions **54, 56** are compressed due to placement of the first and second components **44, 48** on the device **40**, the beam contacts **54, 56** move in an arc, thereby generating sideways wipe forces. According to various embodiments of the present invention, in order to mitigate the problematic cumulative sideways wipe forces of the contacts in the prior art, a first portion of the conductors **50** of the interconnect device **40** may face one direction and a second portion of the conductors **50** may face an opposite direction. That is, for example, with reference to FIG. **5**, the beam contact portions **54, 56** in channels **58***a*, **58***c* may face one direction (down and to the right in FIG. **5**) and the beam contact portions **54, 56** in channels **58***b*, **58***d* may face in the opposite direction (up and to the left in FIG. **5**). When the number of beam contact portions **54** facing the first direction equals the number of beam contact portions **54** oriented to face the second (opposite) direction, the cumulative wipe forces **61** generated by compression of the beam contacts **54** can be effectively canceled, as shown in the example of FIG. **8**.

FIG. **8** shows an embodiment in which a portion of the frame **52** of the interconnect device **10** is used to align the component **44** on the interconnect device **10**. According to other embodiments, rather than using an alignment feature of the frame **52** to align the component **44**, a post, screw or solder ball, for example, may be used to align the component **44**. Canceling sideways swipe forces can be especially advantageous for such alignment techniques because these small features are typically less able to withstand the cumulative sideways swipe forces involved in conventional designs.

According to various embodiments, the orientation of the conductors **50** may alternate by channel **58**, as shown in the example of FIGS. **4–7**. That is, the conductors **50** in every other channel **58** may be oriented in the first direction and the conductors in the intervening channels **58** may be oriented in the opposite direction. Thus, the configuration of the conductors **50** may be considered to be an array of

columns and rows, with the columns being in the direction of the contact beams **54**, **56** (i.e., along the channels **58**) and the rows being cross ways to the contact beams **54**, **56**. Orienting the conductors **50** in a particular column (i.e., channel **58**) in the same direction may simplify manufacture and keep conductors pointed in one direction from interfering with conductors in the other direction.

According to alternative embodiments, rather than an every-other-one arrangement, the conductors in two (or more) adjacent channels may face the first direction and the conductors in the adjacent two (or more) channels may face the opposite direction (an every-other-two arrangement), and so on. When the number of conductors **50** in the first direction roughly equals the number of conductors **50** in the opposite direction, the cumulative wipe forces generated by compression of the beam contacts can be effectively canceled. That is, the vector sum of the wipe forces may approximately equal zero. The number of conductors oriented in the first direction need not exactly equal the number in the opposite direction. According to various other configurations, the conductors may be oriented in more than two different directions (such as three or four different directions), such that the vector sum of the cumulative wipe forces approximately equals zero. According to other embodiments, the vector sum of the cumulative wipe forces may be less that some threshold, such as the amount of force that the alignment device can easily withstand, such five pounds or less.

According to various embodiments, a midsection of the electrical conductors **50** may be molded in place in the frame **52** such that the beam contact portions **54**, **56** extend outwardly from the frame **52** on the upper and lower sides, respectively, thereof. The beam contact portions **54**, **56** may be shaped before or after the midsections of the conductors **50** are molded into place within the frame **52**. As shown in FIGS. **6** and **7**, the opposite direction contact beams may be offset such that, when compressed, the contact tips **62** are in line or a set offset distance from each other.

According to other embodiments, the frame **52** may define a plurality of holes, and the mid-portions of the conductors **50** may be disposed in the holes. Also, according to various embodiments, the frame **52** may be flat and therefore not include channels or ribs **58**, as shown in FIGS. **4**–**7**.

In the illustrated embodiments of FIGS. **4**–**7**, the beam contacts **54**, **56** on each side of the interconnect device **40** are oriented to cancel the sideways wipe forces. According to various other embodiments, only the beam contacts on one side of the interconnect device **40** (such as the beam contacts **54** on the upper side of the frame **52**) may be oriented to cancel the sideways wipe forces. Also in the illustrated embodiments of the FIGS. **4**–**7**, the beam contacts **54**, **56** are shown as compression-type contacts. According to various other embodiments, the contacts on one side of the interconnect device **40** (such as the contacts **54** on the lower side) may be, for example, surface mount soldered (SMT) contacts or ball grid array (BGA) type contacts. For example, the contacts **54** on the upper side of the frame **52** may be pressure-type beam contacts (oriented to cancel sideways swipe forces), and the contacts **56** on the lower side of the frame **52** may comprise, for example, a land **70** with a solder ball **72** connected thereto, as shown in FIGS. **9** and **10**. The solder balls **72** may be connected to the lands **70** prior to connection to the second component **48**, as described in my co-pending U.S. patent application Ser. No. 10/678,250, entitled "Interconnect Apparatus, System, and Method," filed Jan. 30, 2004, which is incorporated herein by reference. Alternatively, the solder balls **72** may be connected to the contacts **46** of the second component **48** prior to connection to the lands **70** of the interconnect device **40**.

Also in the illustrated embodiments of FIGS. **4**–**7**, the channels **58** on the upper and lower sides of the frame **52** are lined up. That is, a channel **58** on the lower side is directly below a channel **58** on the upper side. According to yet other embodiments, the channels **58** on the upper and lower sides of the frame **52** may be offset such that a channel on the lower side is not directly below a channel on the upper side. For more details regarding such embodiments, refer to U.S. Pat. No. 5,967,797, U.S. Pat. No. 6,045,367, U.S. Pat. No. 6,604,950, published U.S. patent application Ser. No. 2002/0160632 and published U.S. patent application Ser. No. 2003/0114025, which are incorporated herein by reference.

While several embodiments of the invention have been described, it should be apparent, that various modifications, alterations and adaptations to those embodiments may occur to persons skilled in the art with the attainment of some or all of the advantages of the present invention. For example, different materials may be used and steps of the disclosed processes may be performed in different orders. It is therefore intended to cover all such modifications, alterations and adaptations without departing from the scope and spirit of the present invention as defined by the appended claims.

What is claimed is:

1. An interconnect device, comprising:

a frame having an upper side and a lower side;

a first plurality of beam contacts on the upper side of the frame for connection to contacts of a first component, wherein the first plurality of beam contacts are arranged such that the sum of the sideways wipe forces caused by compression of the first plurality of beam contacts due to connection of the first component to the interconnect device approximately equals zero; and

a second plurality of contacts on the lower side of the frame for connection to contacts of a second component, wherein each beam contact of the first plurality of contacts is electrically connected to a contact of the second plurality of contacts.

2. The interconnect device of claim **1**, wherein the second plurality of contacts on the lower side of the frame includes beam contacts, and wherein the second plurality of beam contacts are arranged such that the sum of the sideways wipe forces caused by compression of the second plurality of beam contacts due to connection of the second component to the interconnect device approximately equals zero.

3. The interconnect device of claim **1**, wherein the first plurality of beam contacts includes:

a first portion oriented in a first direction; and

a second portion oriented in an opposite direction relative to the first direction.

4. The interconnect device of claim **3**, wherein the number of beam contacts of the first portion equals the number of beam contacts of the second portion.

5. The interconnect device of claim **2**, wherein:

the first plurality of beam contacts includes a first portion oriented in a first direction and a second portion oriented in an opposite direction relative to the first direction; and

the second plurality of beam contacts includes a third portion oriented in the first direction and a fourth portion oriented in the opposite direction.

6. The interconnect device of claim **5**, wherein:

for the first plurality of beam contacts, the number of beam contacts of the first portion equals the number of beam contacts of the second portion; and

for the second plurality of beam contacts, the number of beam contacts of the third portion equals the number of beam contacts of the fourth portion.

7. The interconnect device of claim **1**, wherein:

the first component includes an integrated circuit; and

the second component includes a printed circuit board.

8. An interconnect device, comprising:

a frame having an upper side and a lower side;

a first plurality of beam contacts on the upper side of the frame for connection to contacts of a first component, wherein the first plurality of beam contacts are arranged in columns such that the beam contacts in a first portion of the columns are oriented in a first direction and the beam contacts in a second portion of the columns are oriented in an opposite direction relative to the first direction, such that the sum of the sideways wipe forces caused by compression of the beam contacts in the first and second portions of the columns due to connection of the first component to the interconnect device approximately equals zero; and

a second plurality of contacts on the lower side of the frame for connection to contacts of a second component, wherein each beam contact of the first plurality of contacts is electrically connected to a contact of the second plurality of contacts.

9. The interconnect device of claim **8**, wherein first and second portions of the columns are arranged in an every-other-one arrangement.

10. The interconnect device of claim **8**, wherein the second plurality of beam contacts are arranged in columns such that the beam contacts in a first portion columns on the lower side of the frame are oriented in the first direction and the beam contacts in a second portions of the columns on the lower side of the frame are oriented the opposite direction, such that the sum of the sideways wipe forces caused by compression of the beam contacts in the first and second portions of the columns due to connection of the second component to the interconnect device approximately equals zero.

11. An assembly, comprising:

a first component having a plurality of contacts;

a second component having a plurality of contacts; and

an interconnect device connected between the first and second components, wherein the interconnect device includes:

a frame having an upper side and a lower side;

a first plurality of beam contacts on the upper side of the frame for connection to the contacts of the first component, wherein the first plurality of beam contacts are arranged such that the sum of the sideways wipe forces caused by compression of the first plurality of beam contacts due to connection of the first component to the interconnect device approximately equals zero; and

a second plurality of contacts on the lower side of the frame for connection to the contacts of the second component, wherein each beam contact of the first plurality of contacts is electrically connected to a contact of the second plurality of contacts.

12. The assembly of claim **11**, wherein the second plurality of contacts on the lower side of the frame includes beam contacts, wherein the second plurality of beam contacts are arranged such that the sum of the sideways wipe forces caused by compression of the second plurality of beam contacts due to connection of the second component to the interconnect device approximately equals zero.

13. The assembly of claim **11**, wherein the first plurality of beam contacts includes:

a first portion oriented in a first direction; and

a second portion oriented in an opposite direction relative to the first direction.

14. The assembly of claim **13**, wherein the number of beam contacts of the first portion equals the number of beam contacts of the second portion.

15. The assembly of claim **12**, wherein:

the first plurality of beam contacts includes a first portion oriented in a first direction and a second portion oriented in an opposite direction relative to the first direction; and

the second plurality of beam contacts includes a third portion oriented in the first direction and a fourth portion oriented in the opposite direction.

16. The assembly of claim **15**, wherein:

for the first plurality of beam contacts, the number of beam contacts of the first portion equals the number of beam contacts of the second portion; and

for the second plurality of beam contacts, the number of beam contacts of the third portion equals the number of beam contacts of the fourth portion.

17. The assembly of claim **11**, wherein:

the first component includes an integrated circuit; and

the second component includes a printed circuit board.

18. A method of fabricating an interconnect device for electrically interconnecting a first component to a second component, comprising:

molding a frame of the interconnect device such that a plurality of electrical conductors are molded into the frame, each electrical conductor having a first beam contact portion extending from an upper side of the frame and a second beam contact portion extending from a lower side of the frame; and

shaping the electrical conductors such that the first beam contact portions extending from the upper side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the first beam contact portions due to connection of the first component to the interconnect device approximately equals zero.

19. The method of claim **18**, wherein shaping the electrical conductors further includes shaping the electrical conductors such that the second beam contact portions extending from the lower side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the second beam contact portions due to connection of the second component to the interconnect device approximately equals zero.

20. The method of claim **18**, wherein the shaping step occurs after the molding step.

21. An interconnect device for electrically interconnecting a first component to a second component, comprising:

a frame having an upper side and a lower side;

a plurality of electrical conductors contacting the frame, wherein each of the plurality of conductors includes an upper beam contact, a lower contact, an a midsection therebetween, wherein:

the upper beam contacts are for connection to contacts of the first component;

the lower contacts are for connection to contacts of the second component; and

the upper beam contacts are arranged such that the sum of the sideways wipe forces caused by compression

of the upper beam contacts due to connection of the first component to the interconnect device approximately equals zero.

22. The interconnect device of claim **21**, wherein the lower contacts include lower beam contacts, and wherein the lower beam contacts are arranged such that the sum of the sideways wipe forces caused by compression of the upper beam contacts due to connection of the second component to the interconnect device approximately equals zero.

23. The interconnect device of claim **21**, wherein the midsection of at least one of the electrical conductors is molded in the frame.

24. The interconnect device of claim **21**, wherein the midsection of at least one of the electrical conductors is disposed in a hole defined by the frame.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,971,885 B2
APPLICATION NO. : 10/780936
DATED : February 18, 2004
INVENTOR(S) : Thomas E. Mowry et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On Title Page Item (57)

ABSTRACT

Line 3, delete "includes a frame having a upper side and a lower side" and substitute therefor --includes a frame having an upper side and a lower side--.

COLUMN 1

Line 52, delete "a interconnect device." and substitute therefor --an interconnect device--.

COLUMN 2

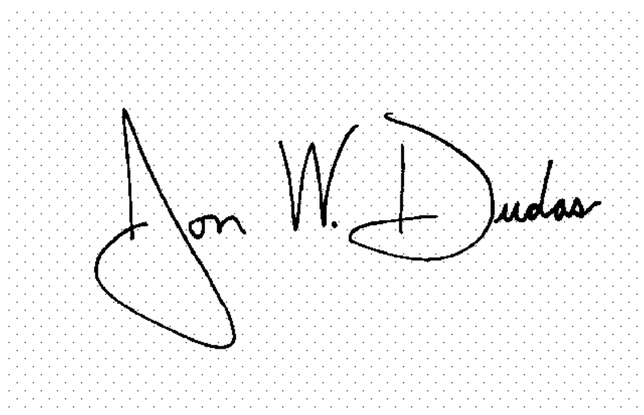
Line 17, delete "a frame having a upper side and a lower side" and substitute therefor --a frame having an upper side and a lower side--.

COLUMN 8

Line 60, delete "an a midsection" and substitute therefor --and a midsection--.

Signed and Sealed this

Twenty-sixth Day of December, 2006



JON W. DUDAS
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,971,885 B2
APPLICATION NO. : 10/780936
DATED : December 6, 2005
INVENTOR(S) : Thomas E. Mowry et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

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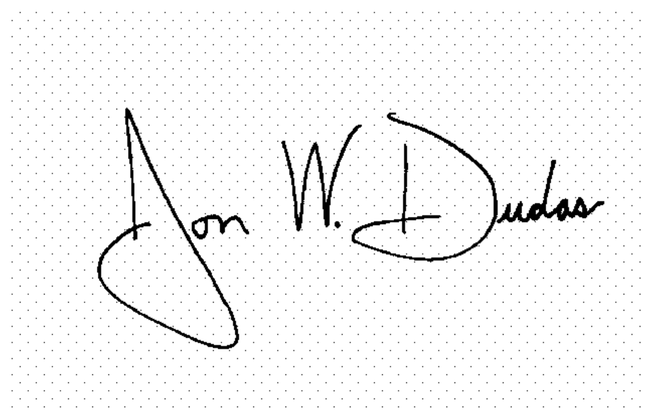
This certificate supersedes Certificate of Correction issued December 26, 2006.

Signed and Sealed this

Thirtieth Day of January, 2007



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